Microchannel Plates and Readout Techniques for Photon and Particle Detection

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ABSTRACT

Microchannel plate detectors have provided considerable utility in many photon counting-imaging applications, from time of flight mass spectroscopy, to Astronomical imaging and spectroscopy in the UV. Recent developments have made significant improvements in MCP detector performance which allow new applications and problems to be addressed, including biological fluorescence lifetime imaging, 3D (X,Y,T) TOF and adaptive optics. Advances in photocathodes (GaN, Diamond), microchannel plates (Silicon MCP's), and readouts (Cross strip) are poised to make a significant impact on the capabilities of future space instruments. Novel GaN photocathodes have achieved >60% DQE in the UV (100nm – 400nm), in addition diamond photocathodes have been made with 40% DQE and bandpass cutoff of 200nm. Devices with GaAs high QE cathodes in the visible are also planned. Silicon based MCP's of 25mm format with ~7μm pores, have been made, achieving gain of nearly 10^4 for single Si MCP's with background is as low as ~ 0.02 events sec^{-1} cm^{-2}, the best for any MCP. The flat fields are free of any periodic modulation, and Silicon MCP's have low stopping power for X, gamma and cosmic rays. Meanwhile cross delay line anodes have provided excellent performance for imaging and timing. New cross strip anodes based on multi-layer metal and ceramic multilayer strip patterns encode event positions by direct sensing/centroiding of the charge on each strip. The spatial resolution (<3mm) achieved is sufficient to resolve 7mm microchannel plate pores while using low MCP gain (≈4 x 10^5) on 32mm format (>5k x 5k). Image linearity is good enough to see distortions in the microchannel plate pore alignment, and the low MCP gain substantially enhances the overall lifetime of MCP detector systems. New ASIC pixel (CMOS) readouts are also under development and offer very high event rate capability with modest spatial resolutin. These advances represent factors of five to ten improvements over current devices, and will afford substantial advantages for new instruments.